Medical Costs Associated With Diabetes Complications in Medicare Beneficiaries Aged 65 Years or Older With Type 1 Diabetes

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EPIDEMIOLOGY/HEALTH SERVICES RESEARCH

OBJECTIVE

To estimate medical costs associated with 17 diabetes complications and treatment procedures among Medicare beneficiaries aged ≥65 years with type 1 diabetes.

RESEARCH DESIGN AND METHODS

With use of the 2006–2017 100% Medicare claims database for beneficiaries enrolled in fee-for-service plans and Part D, we estimated the annual cost of 17 diabetes complications and treatment procedures. Type 1 diabetes and its complications and procedures were identified using ICD-9/ICD-10, procedure, and diagnosis-related group codes. Individuals with type 1 diabetes were followed from the year when their diabetes was initially identified in Medicare (2006–2015) until death, discontinuing plan coverage, or 31 December 2017. Fixed-effects regression was used to estimate costs in the complication occurrence year and subsequent years. The cost proportion of a complication was equal to the total cost of the complication, calculated by multiplying prevalence by the per-person cost divided by the total cost for all complications. All costs were standardized to 2017 U.S. dollars.

RESULTS

Our study included 114,879 people with type 1 diabetes with lengths of follow-up from 3 to 10 years. The costliest complications per person were kidney failure treated by transplant ($77,809 in the occurrence year and $13,556 in subsequent years), kidney failure treated by dialysis ($56,469 and $41,429), and neuropathy treated by lower-extremity amputation ($40,698 and $7,380). Sixteen percent of the total medical cost for diabetes complications was for treating congestive heart failure.

CONCLUSIONS

Costs of diabetes complications were large and varied by complications. Our results can assist in cost-effectiveness analysis of treatments and interventions for preventing or delaying diabetes complications in Medicare beneficiaries aged ≥65 years with type 1 diabetes.

Type 1 diabetes is a chronic condition that increases the risk for many serious health problems, including macrovascular and microvascular complications. Type 1 diabetes imposes large economic burdens on the health care system and on families

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of people who have the disease (1). The number of Medicare beneficiaries with type 1 diabetes has been increasing and is expected to continue to grow because of increases in prevalence and incidence of type 1 diabetes in the younger population (2,3) and increases in life expectancy of people with type 1 diabetes (4). Assessing and reducing the economic burdens of type 1 diabetes have become increasingly important for Medicare.

Many interventions, such as managing HbA_{1c}, blood pressure, and cholesterol, could prevent or delay the onset of diabetes complications in people with type 1 diabetes (5,6). Assessing the cost effectiveness of these interventions requires information about the costs of individual complications to quantify the medical costs saved from preventing or delaying the complication. Simulation models have been developed for assessing the long-term cost effectiveness of type 1 diabetes interventions, as the health and economic benefits of the interventions may not be realized immediately after initiating the intervention (7). Improving the parameterization of the simulation model requires current and accurate cost estimates of individual diabetes complications. Furthermore, assessing the need for health care resources of Medicare beneficiaries with type 1 diabetes requires estimates of the cost of diabetes complications.

Few prior studies have examined the cost of type 1 diabetes in the U.S., and these studies were mainly focused on estimating the total medical cost attributable to type 1 diabetes in people aged ≤65 years (8,9). Medical costs of Medicare beneficiaries with type 1 diabetes likely differ from the costs derived from a younger population because of differences in the type of health insurance, duration of diabetes, and health profiles of the study population. Furthermore, estimates of the total medical cost of type 1 diabetes are of limited use for measuring the economic benefits of interventions for preventing different types of complications (10). Due to a lack of cost estimates by type of complication, existing type 1 diabetes simulation models either use cost estimates derived from the type 2 diabetes population as proxies or synthetic estimates derived from a microcosting model based on recommended treatment patterns (7,11). Costs of the same diabetes complication among people with type 1 and type 2 diabetes likely differ because of age at diabetes onset, duration of diabetes, and management of the disease (12–15).

As the costs of diabetes complications in the older adult type 1 diabetes population are largely unknown, the objective of our study was to estimate the annual cost of individual complications in Medicare beneficiaries aged ≥65 years with type 1 diabetes. Leveraging a large type 1 diabetes population included in the 100% Medicare claims data, we estimated the cost of 17 diabetes complications and treatment procedures in this population.

RESEARCH DESIGN AND METHODS

Study Population

Our study sample was from a diabetes cohort previously identified (16) using 100% Medicare claims among those who enrolled in fee-for-service plans. This cohort contained Medicare beneficiaries ≥68 years old with diagnosed diabetes, including both type 1 and type 2 diabetes. The algorithm used to identify beneficiaries' diabetes status through claims was validated and described in detail previously (16,17). We used ICD-9 code 250.x1 or ICD-10 code E10 for type 1 diabetes and ICD-9 code 250.x0 or ICD-10 code E11 for type 2 diabetes to distinguish between the two diabetes types. In our analysis, we included beneficiaries with type 1 diabetes claims only or beneficiaries with more type 1 diabetes claims than type 2 diabetes claims if they had both type 1 and 2 diabetes codes in their claims (18). We did not include beneficiaries enrolled in Medicare Advantage Plans, who represent approximately one-third of the total Medicare population (19), because we did not have claims data for them. We also excluded beneficiaries who did not enroll in Part D plans because their prescription drug cost data were not available.

The first cohort from the database was from 2008. We required the beneficiaries to have a minimum of 2 years of follow-up after the year when they were initially identified with a type 1 diabetes diagnoses. Using data from 2008 to 2017, we identified eight cohorts (one cohort in each year 2008–2015 plus at least 2 years of follow-up) of beneficiaries with type 1 diabetes.

Outcome Variable

The outcome variable for our analysis was the total annual per-person medical cost paid by Medicare, beneficiaries, and any third-party payers. Total cost included costs associated with inpatient, outpatient, home, and skilled nursing facility care; prescription drugs; and medical supplies. Data on costs of prescription drugs were available only for beneficiaries enrolled in Part D plans. All costs were adjusted to 2017 U.S. dollars using the Personal Health Care expenditures deflator (20).

Diabetes Complications

Diabetes complications and treatment procedures were the primary variables of interest. We used diagnosis and procedure codes and diagnosis-related group codes (Supplementary Table 1) to identify 17 diabetes complications. To precisely capture the cost pattern of different complications, we categorized the complications according to their natural histories and the associated treatment patterns and modeled their costs accordingly. Complications were categorized into two groups: *1*) acute events that did not have costs in subsequent years and *2*) chronic events with different cost estimates in the year when the complication occurred (i.e., occurring year) and in subsequent years. The first group included retinopathy intravitreal injections, photocoagulation, hypoglycemia, and ketoacidosis. The second group included the rest of the complications, with some modifications, for nephropathy, kidney failure treated by dialysis, kidney failure treated by transplant, myocardial infarction (MI), stroke, angina, and revascularization. Because of the progressive nature of chronic kidney disease and treatment options, we set dummy variables associated with nephropathy and nephropathy history to be equal to zero when either dialysis or transplant occurred. Similarly, we set dummy variables associated with dialysis and dialysis history to be equal to zero at the year or afterward when a person had a transplant. For MI and stroke, we allowed recurrent occurring years whenever there was one or more claims for acute events in the year. We treated angina and revascularization the same as MI and stroke with exceptions; whenever MI or MI history variables and angina or revascularization history variables appeared in the records, we set the value of angina or revascularization history as zero to recognize that MI would absorb the effect of angina or revascularization during subsequent years (Supplementary Table 2). If a beneficiary had a complication before 2008, we treated the complication status as a subsequent year. All subsequent years were grouped into one variable instead of being counted as separate variables, such as subsequent year 1, subsequent year 2, etc.

Statistical Methods and Model Selection

As the proportion of beneficiaries with diabetes who had a zero total annual cost was <1%, we used a one-equation regression model as opposed to a two-part model. We used the fixed-effects model for our analysis. Unlike cross-sectional studies that use cross-sectional data to compare medical costs between people with and without a specific complication, the fixed-effects model uses longitudinal data to compare medical costs of a person before and after the person has a complication. Many factors, such as those related to health care–seeking behaviors, perceived health status, or ability to pay, affect health service utilization and medical costs but are often unavailable in claims data. Omitting these variables could lead to estimate biases. The fixed-effects regression model can inherently adjust for these factors with missing data but do not change over time to reduce the estimation biases (21) (Supplementary Materials). We controlled for several comorbid conditions, including liver disease, arthritis, depression, hip fracture, anemia, dementia, asthma, chronic obstructive pulmonary disease, hypothyroidism, cancer, HIV/AIDS, and organ transplant (excluding kidney or pancreas transplants that could result from having diabetes), to adjust for potential confounding. Our cost estimates represented an independent assessment of a specific complication, not the total cost among beneficiaries who experienced that complication, which could be much higher because complications co-occur. All descriptive and regression analyses were performed using SAS Enterprise Guide 7.1 software (SAS Institute, Cary, NC). We also conducted a subgroup analysis that provided complication cost estimates by age (<75, ≥75 and <85, ≥85 years), race/ethnicity (Black, White, Hispanic, Asian/Pacific Islander, American Indian/Alaska Native), and dual eligibility for Medicaid (yes/no).

We estimated the total cost for each complication and its proportion in the overall cost of all complications in 2017 for Medicare fee-for-service beneficiaries with type 1 diabetes and Part D enrollment. The total cost of an individual complication was calculated by multiplying prevalence of the complication in the beneficiaries with type 1 diabetes and Part D enrollment by the estimated annual per-person cost from the fixed-effects regression model. The overall cost associated with all complications was the cost sum of all 17 complications. The cost proportion of each complication was the cost of each complication divided by the overall total.

To estimate the total medical cost associated with diabetes complications for all Medicare beneficiaries with type 1 diabetes in 2017, we conducted a sensitivity analysis by including beneficiaries both with and without Part D. The method used to estimate the annual cost associated with each complication was the same as the main analysis except that we added a dummy variable for those who did not enroll in Part D. We used the same method as used for the main analysis to estimate the total cost for an individual complication and for all 17 complications in the sensitivity analysis.

RESULTS

Our study included 114,879 Medicare fee-for-service beneficiaries with type 1 diabetes. The 2008 cohort had the longest follow-up time and the largest share (61.1%) of beneficiaries, as it included those who were enrolled in Medicare before 2008 (Supplementary Table 3). The average follow-up time was 5.73 years (range 3–10 years). Table 1 shows the characteristics of the study population in patients' baseline year. Individuals were, on average, 77 years old when they entered the study. The majority were non-Hispanic White (77.6%), and more than one-half (63.3%) were female. Approximately one-half (49.3%) had at least one complication, and 2.8% had four or more complications at baseline. Having a complication increased the crude medical cost. The most common complications were nephropathy (74.3%) and congestive heart failure (CHF) (67.8%). The least common complications were kidney transplant (0.2%), ketoacidosis (1.1%), and lower-extremity amputation (1.6%) (Supplementary Table 9).

The estimated annual per-person costs associated with diabetes complications after adjusting for time-invariant characteristics of beneficiaries themselves ranged from $40 (chronic retinopathy history) to $77,809 (kidney failure treated by transplant), with a median cost of $5,799 (Table 2 and Supplementary Fig. 1). The two short-term complications of hypoglycemia and ketoacidosis cost $6,400 and $11,204, respectively. The three costliest long-term conditions were all microvascular complications, including kidney failure treated by transplant ($77,809 in the occurrence year and $13,556 in subsequent years), kidney failure treated by dialysis ($56,469 and $41,429), and lower-extremity amputation ($40,698 and $7,380). Costs for other microvascular complications ranged from $872 to $10,639 in the occurrence year and $40 to $3,090 in subsequent years (Table 2 and Supplementary Fig. 1).

The costliest condition among macrovascular complications was MI ($18,575 in the occurrence year and $1,488 in subsequent years). Other macrovascular complications cost $12,813 in the occurrence year and $3,229 in subsequent year for CHF, $12,385 and $542 for stroke, $11,608 and $816 for revascularization, and $5,198 and $553 for angina (Table 2 and Supplementary Fig. 1).

Results of the subgroup analysis are provided in Supplementary Tables 5–7. Differences in annual complication costs among subgroups varied depending on the specific complication. Overall, Black beneficiaries and beneficiaries with dual eligibility for Medicaid had a higher cost estimate for diabetes complications. There was no clear pattern in the cost of complications by age-group.

The estimated total cost for all 17 complications in Medicare fee-for-service beneficiaries with type 1 diabetes and Part D enrollment was $704.4 million in 2017. Total cost of CHF (occurrence and subsequent years) was the highest among the 17 complications, accounting for 16% of the total (Supplementary Table 4). Second to CHF was nephropathy at 14% of the total. Stroke represented 13% of the total; revascularization, 12%; kidney failure treated by dialysis, 11%; MI, 10%; and foot ulcer, 8%. Each other complication represented <5% of the total. Although kidney failure treated by

Table 1—Demographic and clinical characteristics of Medicare beneficiaries in the year first identified as having type 1 diabetes

	Mean
Sample size, *N*	114,879
Age (years), mean	76.92
Sex, %	
Female	63.29
Male	36.71
Race/ethnicity, %	
Non-Hispanic White	77.55
Hispanic	7.13
Non-Hispanic Black	11.67
Asian/Pacific Islander	2.77
American Indian/Alaska Native	0.21
Unknown	0.36
Comorbidities, %	
Cancer	33.83
HIV/AIDS	0.28
Organ transplant*	0.07
Number of complications, mean	0.82
Number of diabetes complications,† %	
0	50.66
1	28.65
2	12.81
3	5.13
≥4	2.75

The Medicare beneficiaries whose index year was 2008 included all with type 1 diabetes who were either eligible for the first time or had been with Medicare for some time. *Excluding kidney failure treated by transplant. †Diabetes complications: retinopathy intravitreal injections, photocoagulation, hypoglycemia, ketoacidosis, nephropathy, kidney failure treated by dialysis, kidney failure treated by transplant, neuropathy, lower-extremity amputation, chronic retinopathy, blindness and vision loss, CHF, foot ulcer, MI, stroke, angina, and revascularization.

transplant was the costliest complication per person per year, it accounted for only 0.3% of the total complication cost, as the number of beneficiaries who received this treatment was small.

Results from the sensitivity analysis showed that including beneficiaries without Part D in the study population changed the proportion of individual complications little (Table 3). However, the total estimated cost associated with diabetes complications was increased from $704.7 million to $910.5 million.

CONCLUSIONS

To our knowledge, our study is the first to estimate the cost of a comprehensive set of diabetes complications among Medicare beneficiaries with type 1 diabetes. Unlike the cost of complications in people with type 2 diabetes, the cost associated with complications in people with type 1 diabetes has not been well studied, especially among older adults. Diabetes complications have increased among Medicare beneficiaries with type 1 diabetes because of increases in the number of beneficiaries with the disease (22). Our study estimated the individual and overall burden of complications in Medicare fee-for-service beneficiaries aged ≥65 years with type 1 diabetes.

Our study results indicate that costs of type 1 diabetes complications are substantial and impose large financial burdens on Medicare. A U.K.-based study demonstrated that when patients learned to monitor and manage their blood glucose levels to the recommended target levels or below, their risk of complications and the total medical cost in individuals with type 1 diabetes were reduced (23). Screening for microalbuminuria and retinopathy followed by treatment could lower the risk of kidney failure and blindness and has been found to be cost saving (24,25). Blood pressure control with ACE inhibitors (ACEIs) and angiotensin receptor blockers (ARBs) has been demonstrated as highly effective in preventing kidney failure and in cost saving compared with no ACEI/ARB therapy in patients with type 1 diabetes (6). It may be beneficial to evaluate the cost effectiveness of those interventions in Medicare beneficiaries with type 1 diabetes. If confirmed, implementing these interventions could improve health and lower the cost of diabetes complications in this population.

Yang et al. (26) used a similar study design with claims data from private insurance to estimate the cost of diabetes complications in people aged <65 years with type 1 diabetes. Compared with their cost estimates, ours were higher for hypoglycemia, ketoacidosis, nephropathy, and neuropathy but lower for all other complications. These differences could be due to reasons such as Medicare beneficiaries with type 1 diabetes having a different payment structure (the younger population is mostly covered by private insurance) (10), or the pattern of care for older adults with type 1 diabetes could be different because of age-related conditions and multiple comorbidities and because of the need for social support (27). In addition, our estimated cost for kidney transplant did not include the cost of organ acquisition, including expenditures associated with tissue typing, crossmatching, and transportation of living donors or their kidneys and the associated administrative costs. The cost of kidney transplant would be higher than our estimates if these costs were included. However, the cost after the first year of kidney transplant would be much lower.

Studies to estimate costs of diabetes complications have also been conducted in other countries, mainly among people with type 2 diabetes (28–32). Cost estimates from these studies are not directly comparable to ours because of different diabetes type, health care systems, and payment policies in those countries. However, ranking of the estimated cost by complication seems to share some similarities. For example, the two most expensive complications were renal failure treated by dialysis or transplant and amputation. Retinopathy was the least expensive complication.

With the use of the same database and study design, we also estimated the cost of diabetes complications among Medicare beneficiaries aged ≥65 years with type 2 diabetes (33). Compared

Table 2—Estimated annual per-person diabetes complication costs in Medicare beneficiaries with type 1 diabetes, in 2017 U.S. dollars

Complications	Estimated cost	SE
Short-term		
Hypoglycemia	6,400.2	155.3
Ketoacidosis	11,204.4	717.2
Microvascular		
Nephropathy	10,263.6	148.3
Nephropathy history	2,321.0	142.9
Kidney failure treated by dialysis	56,469.2	504.3
Kidney failure treated by dialysis history	41,429.3	543.1
Kidney failure treated by transplant	77,808.9	3,000.4
Kidney failure treated by transplant history	13,555.8	2,586.0
Neuropathy	4,434.2	182.8
Neuropathy history	1,168.3	161.2
Foot ulcer	10,639.3	198.0
Foot ulcer history	3,090.4	183.9
Lower-extremity amputation	40,697.7	776.5
Lower-extremity amputation history	7,379.8	932.0
Chronic retinopathy	871.8	279.0
Chronic retinopathy history	39.8	233.1
Retinopathy intravitreal injections	3,959.4	253.6
Photocoagulation	1,404.5	234.7
Blindness and vision loss	6,770.7	302.2
Blindness and vision loss history	739.7	271.3
Macrovascular		
CHF	12,812.6	161.4
CHF history	3,228.8	158.8
MI	18,575.1	203.2
MI history	1,488.2	200.6
Stroke	12,384.7	152.7
Stroke history	541.7	179.9
Angina	5,197.5	186.3
Angina history	552.9	225.1
Revascularization	11,608.0	168.9
Revascularization history	815.5	256.6

with cost estimates of complications in people with type 2 diabetes, our estimates in people with type 1 diabetes were lower for hypoglycemia ($6,400 for type 1 vs. $9,399 for type 2; 47% lower), ketoacidosis ($11,204 vs. $13,015; 16% lower), and kidney failure treated by transplant history ($13,556 vs. $15,568; 15% lower). Our type 1 diabetes cost estimates were higher for nephropathy history ($2,321 vs. $1,875; 19% higher), neuropathy history ($1,168.3 vs. $870.7; 25% higher), foot ulcer history ($3,090 vs. $2,303; 25% higher), blindness and vision loss history ($740 vs. $447; 40% higher), chronic retinopathy ($872 vs. $682; 22% higher), and revascularization history ($816 vs. $576; 29% higher). Differences in all other estimates by diabetes type were within 15%. The reasons for the differences and similarities in complication costs between beneficiaries with type 1 and type 2 diabetes are not clear. Differences in diabetes management, severity of the complications, obesity, or other characteristics of the two study populations could play a role. For example, previous studies showed that severe hypoglycemia happens more often in patients with type 2 diabetes than type 1 diabetes (34,35), which could lead to a higher cost for treating hypoglycemia in beneficiaries with type 2 diabetes.

Our cost estimates by individual complication can be used as a benefit measure to evaluate the medical costs that could be saved by interventions that can prevent or delay various diabetes complications. Furthermore, our cost equation can be directly programmed into type 1 diabetes simulation models to measure the cost of complications in people aged ≥65 years. In some of the current type 1 diabetes simulation models, estimates are derived from a type 2 diabetes population of all ages. If those estimates are replaced by our estimates, which were derived from older adults with type 1 diabetes, accuracy of the cost-effectiveness results generated by these models would improve. Since our estimates were generated from the Medicare fee-for-service population aged ≥65 years with type 1 diabetes, these cost estimates may not be appropriate estimates for predicting complication costs in the younger population with type 1 diabetes. CHF and nephropathy accounted for 30% of the total cost associated with diabetes complications in Medicare beneficiaries with type 1 diabetes with fee-for-service health plans in 2017. Efforts focusing on preventing or delaying these two complications could have a substantial effect on reducing the total medical cost associated with diabetes complications in this population. CHF and nephropathy are highly correlated with each other (36,37). Use of ACEIs/ARBs has been shown to be effective in slowing the progression of kidney disease in people with type 1 diabetes (6), as well as in preventing heart failure for people with diabetes (38).

One strength of our study is the large population with long follow-up times, which allows us to estimate all 17 major diabetes complications and produce reliable and accurate cost estimates for each complication. Another strength is the use of a longitudinal study design and an individual-level fixed-effects model, which allowed us to control for all time-invariant characteristics of patients that were not available in insurance claims data. Health care service utilization and cost can be influenced by many other factors besides basic demographic information (age, sex, and race) available in claims data. These factors include health-related behavior patterns, childhood experience, medication adherence, perceived health status, financial security, etc. (39). Use of an individual-level fixed-effects model overcame this limitation of claims data by comparing the outcomes of different complication statuses for the same individual.

Our study has some limitations. First, the panel data are truncated on both the left and the right sides of the follow-up period. Although we created a 2-year lookback period, some patients entered the analysis as having established type 1 diabetes and may have had prior acute complication events that we could not observe. It is possible that patients with established complications had different costs when encountering the second event, which we analyzed as a first event. Second,

Table 3—Estimated per-person per-year cost, frequency, and total cost of each diabetes complication in all Medicare fee-for-service beneficiaries with type 1 diabetes in 2017

Complications	Estimated cost	Frequency	Percentage of total cost
Short-term			
Hypoglycemia	6,247.7	5,244	3.6
Ketoacidosis	10,828.6	879	1.0
Microvascular			
Nephropathy	9,897.1	3,128	3.4
Nephropathy history	2,156.2	41,520	9.8
Kidney failure treated by dialysis	56,318.1	387	2.4
Kidney failure treated by dialysis history	41,397.8	1,841	8.4
Kidney failure treated by transplant	73,868.2	5	0.0
Kidney failure treated by transplant history	12,610.1	178	0.2
Neuropathy	4,472.2	808	0.4
Neuropathy history	1,068.6	35,827	4.2
Foot ulcer	10,280.3	1,466	1.7
Foot ulcer history	2,902.8	19,050	6.1
Lower-extremity amputation	39,318.1	250	1.1
Lower-extremity amputation history	8,131.8	451	0.4
Chronic retinopathy	913.0	20	0.0
Chronic retinopathy history	45.2	27,084	0.1
Retinopathy intravitreal injections	3,991.2	3,778	1.7
Photocoagulation	1,338.1	1,446	0.2
Blindness and vision loss	6,675.8	866	0.6
Blindness and vision loss history	667.3	6,844	0.5
Macrovascular			
CHF	13,076.2	3,713	5.3
CHF history	3,267.6	32,047	11.5
MI	18,469.6	3,855	7.8
MI history	1,305.6	13,927	2.0
Stroke	12,369.2	9,561	13.0
Stroke history	341.9	12,615	0.5
Angina	4,838.7	3,721	2.0
Angina history	479.2	9,754	0.5
Revascularization	11,168.4	9,192	11.3
Revascularization history	431.8	5,146	0.2
Total cost		910,544,059.5	

Estimated and total costs are given in 2017 U.S. dollars.

costs of an initial event may run >2 calendar years, leading to a slight underestimation of acute costs and an overestimation of the costs in subsequent years. Third, approximately one-half of the included individuals had more than one complication. We assumed that the costs of multiple complications are additive. The cost of managing concurrent complications may not equal the sum of the costs of each complication but may have interaction effects, thus increasing or decreasing the overall cost. The effect of two or more coexisting complications on medical costs could differ by complication. Future research is needed to disentangle the cost relationship among complications. Fourth, even without inflation, the cost of complications may have increased over the years because of technological advancement. We therefore might be underestimating the relevant cost for the complications for which treatments have become much more expensive since 2006. Fifth, the algorithm used in our study to identify people with type 1 diabetes versus type 2 diabetes could have misclassified some patients. How this misspecification affected the estimated costs of diabetes-related complications is not clear. Finally, fixed-effects models may not completely eliminate confounding because there are still variables that could change over time.

Costs of individual diabetes complications in older adults with type 1 diabetes were previously unknown. We estimated these costs associated with 17 diabetes complications and treatment procedures among Medicare beneficiaries aged ≥65 years with type 1 diabetes. Our cost estimates provide the cost parameters needed by type 1 diabetes cost-effectiveness simulation models, as well as those needed to determine economic benefits of clinical and public health efforts to delay or prevent complications in Medicare beneficiaries with type 1 diabetes.

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